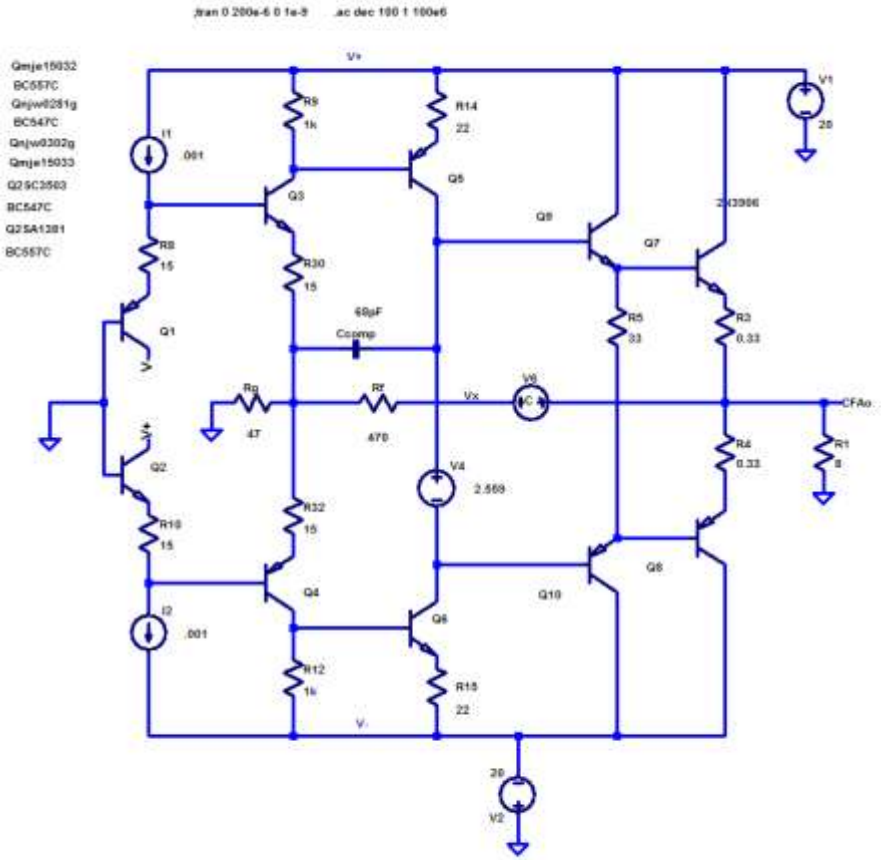
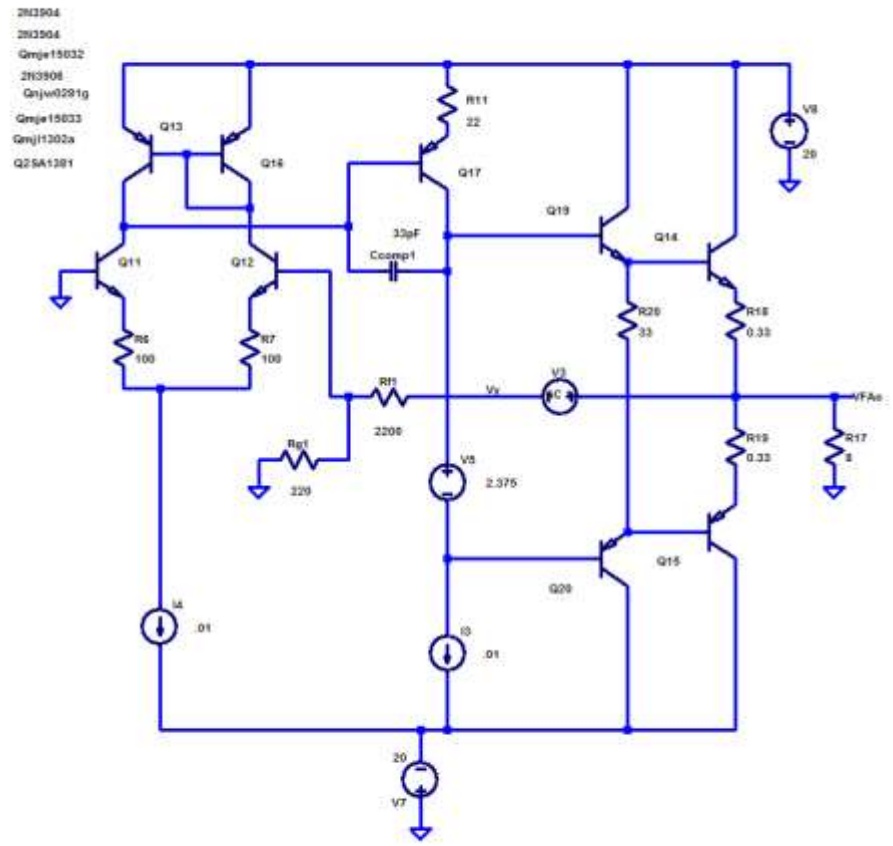
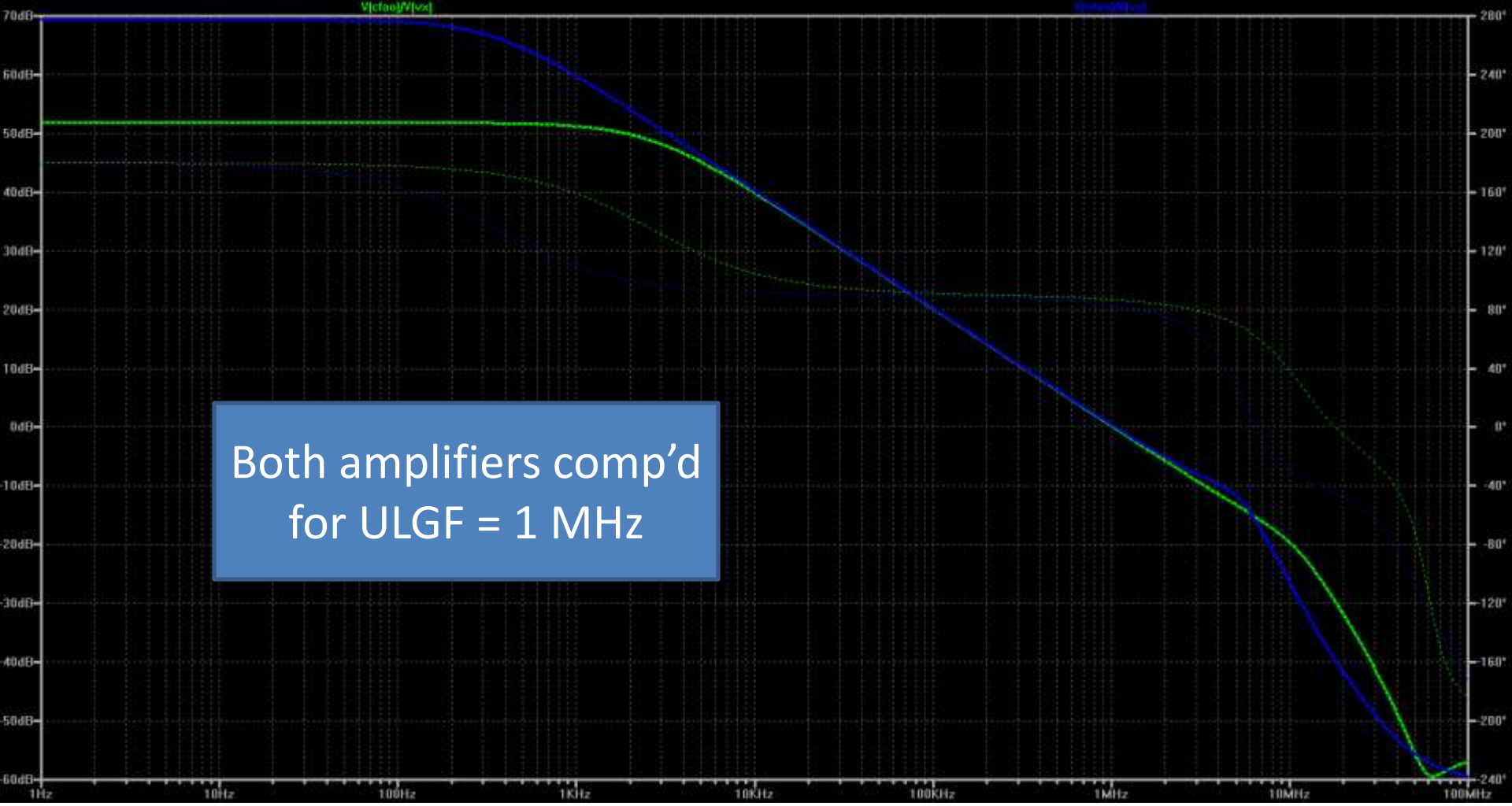




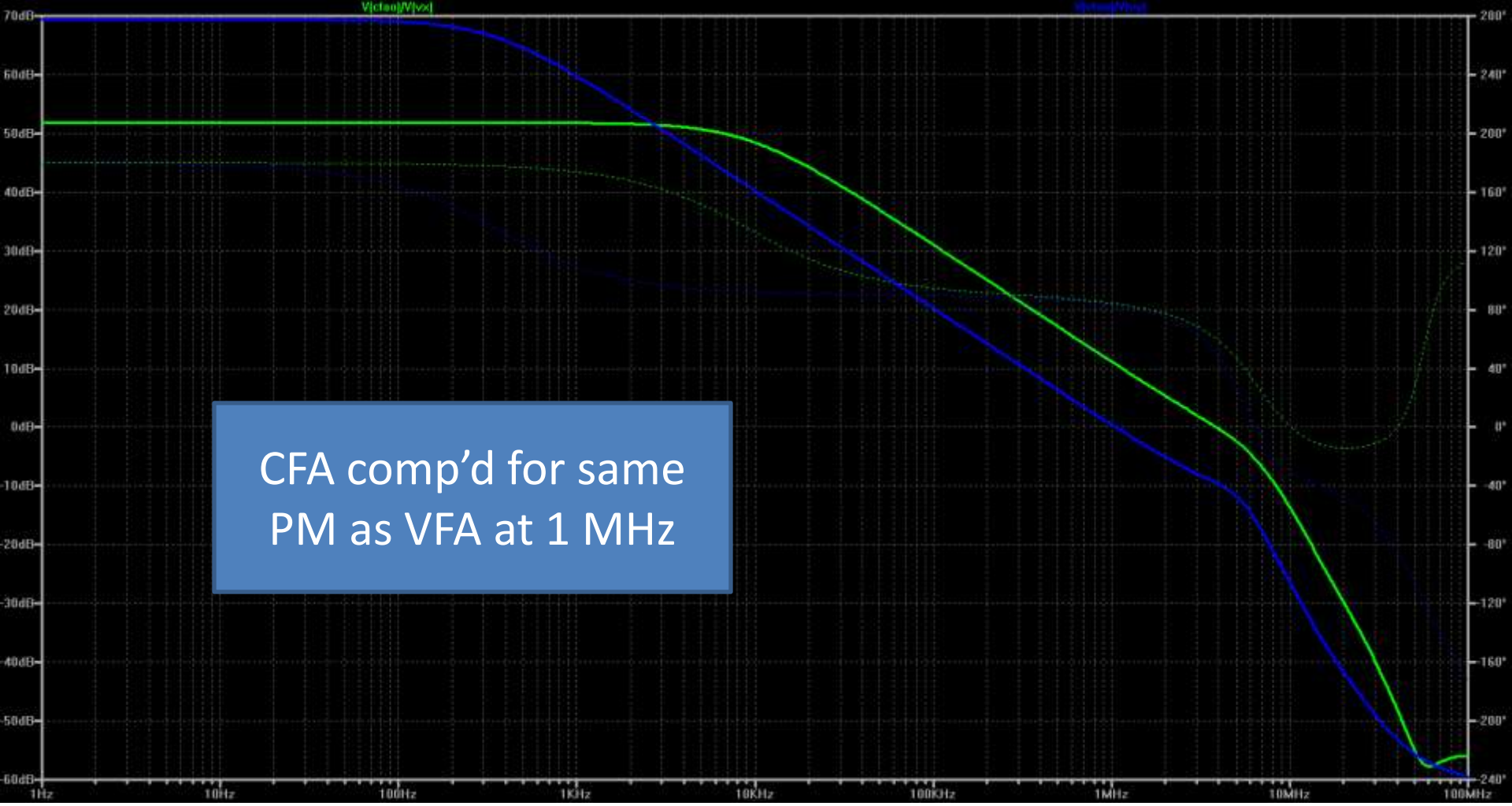
- These are the simple VFA and CFA models used to investigate phase and gain margin behavior between CFA and VFA topology amplifiers
- For simplicity and consistency, the gain for both models is set at 11x or ~21dB
- For the VFA, a classic single ended, current mirror loaded LTP was chosen, while for the CFA a typical diamond buffer driving a single transistor TIS was chosen. In both models, the second stage could have utilized beta helpers to raise the loop gains, but the idea here is to explore the gain phase behavior of the basic topologies, not to try to design high performance amplifiers

- This is the closed loop response for the model amplifiers wherein the CFA is compensated for the *same phase margin* as the VFA's at the VFA ULGF of 1 MHz
- The following slides will demonstrate some of the compensation options explored for the two models in terms of ULGF and associated PM's

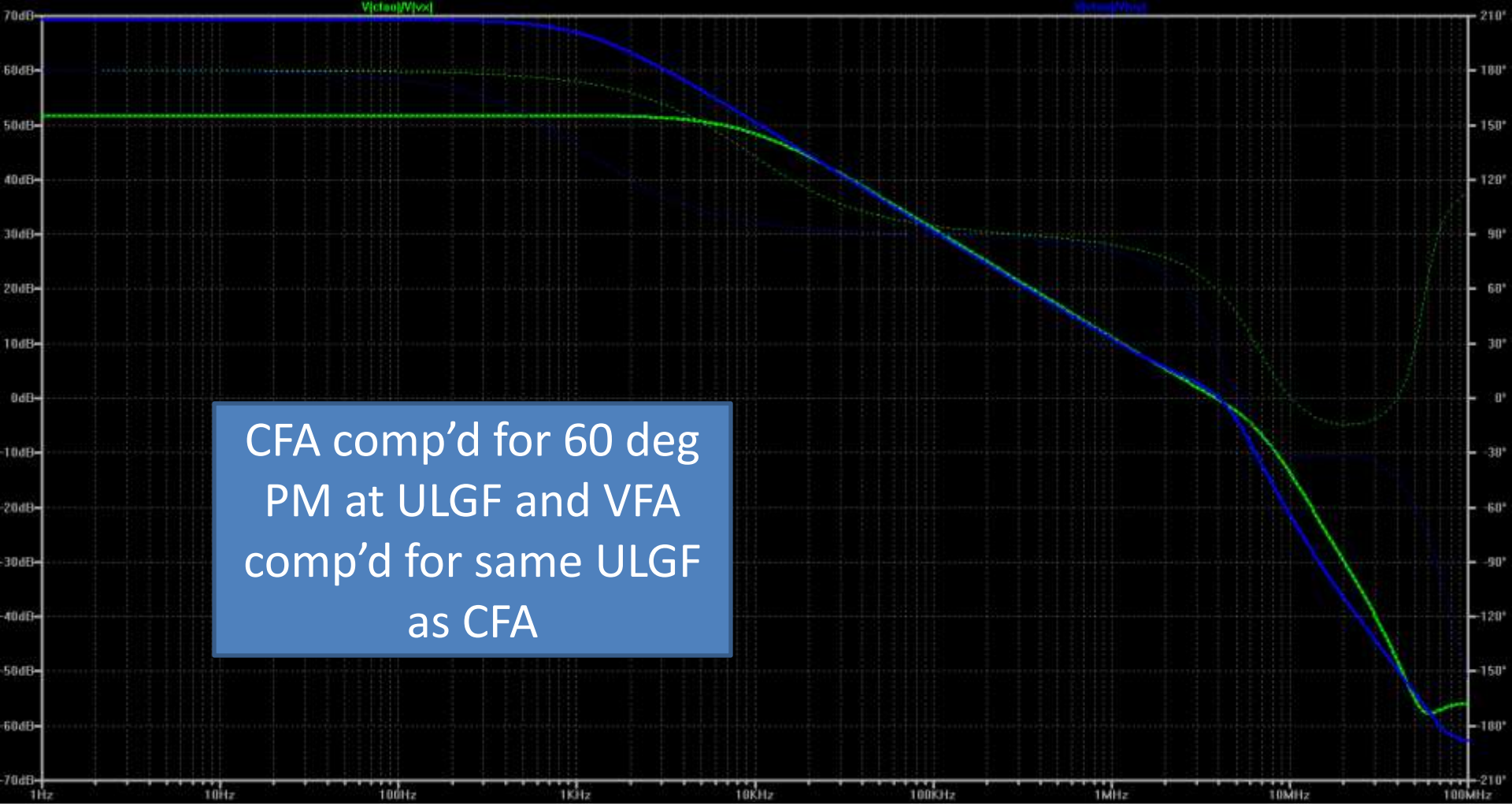
- These are the uncompensated open loop gain plots for the model amplifiers shown for reference. Ccomp in both models set to 1pF
- Both exhibit a UGF of above 10MHz
- The LF VFA OLG is 90 dB while in the CFA it is 72 dB – both typical figures for the respective topology power amplifiers



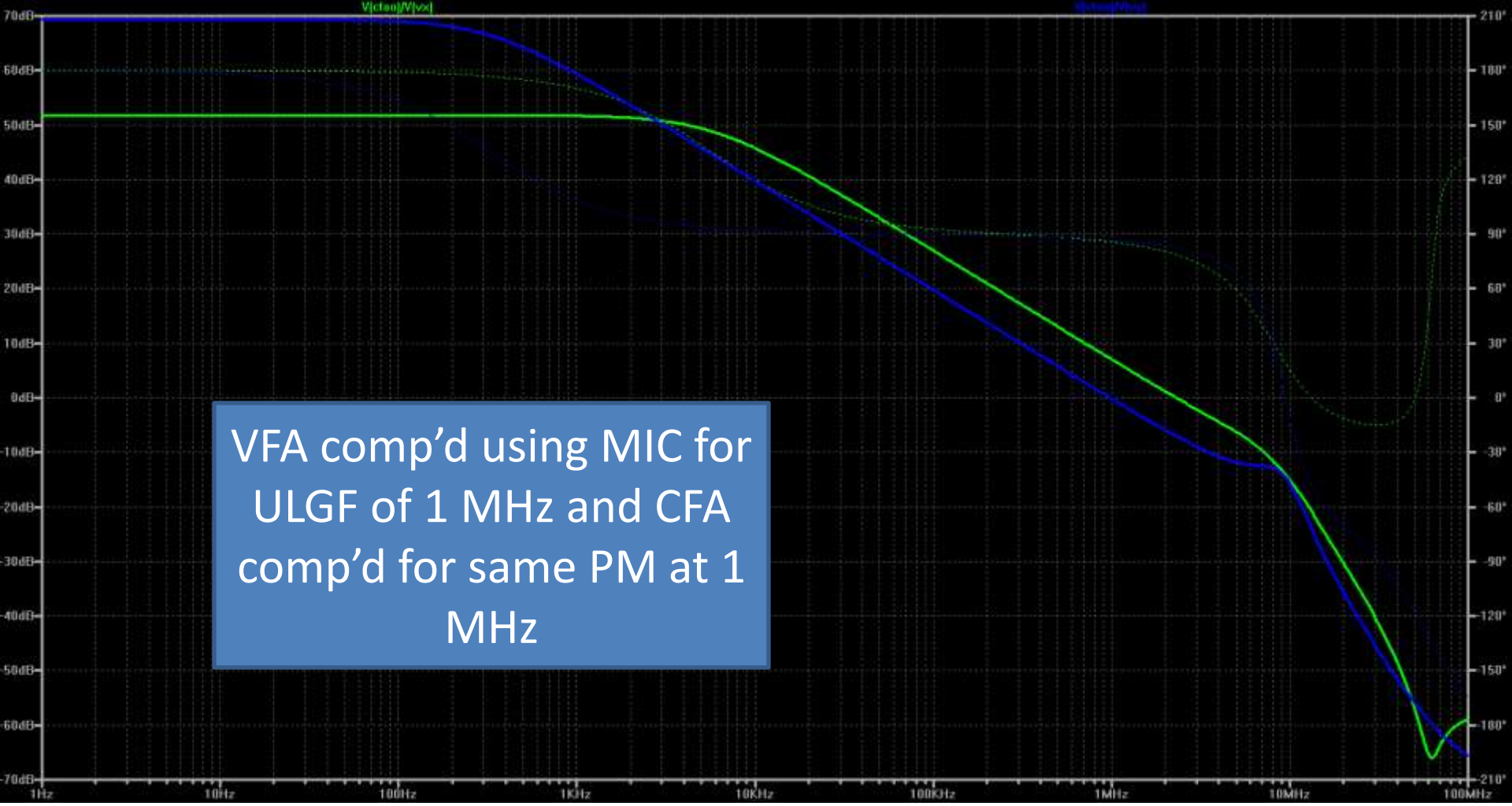
- In this plot, both models were comp'd for 1MHz ULGF
- The phase margins at 1 MHz are similar, but beyond ~3 MHz, the VFA PM drops off rapidly. At 10 MHz, the CFA still has +40 degrees of PM in hand, while the VFA has -40 degrees
- Beyond the CFA -3 dB LG BW, both amplifiers exhibit almost the same response up until the ULGF
- However, given the additional PM in hand in the CFA beyond the ULGF, we could trade this for higher LG at HF by comp'ing it for a higher ULGF which we will look at on the next slide



- Here, the CFA model is comp'd so that it exhibits the same PM as the VFA at 1 MHz (they are within about 1~2 degrees)
- The ULGF of the CFA is now ~3.5 MHz, and the HF loop gain beyond about 10 kHz is 12 dB better than the VFA
- At LF, the VFA loop gain is higher, as expected
- Above the ULGF, the CFA has more GM and PM than the VFA in this model



- In this plot, the CFA has been comp'd for a 60 degree phase margin at its ULGF and then the VFA has been comp'd for the same ULGF
- The VFA PM in this case is about 15 degrees, or about a quarter of the CFA's



- In this plot, the VFA has been comp'd using MIC (Ccomp = 68pF) for a ULGF of 1 MHz
- The CFA is then comp'd for the same PM (the difference is about 1.5 degrees greater PM in the VFA in this example)
- The CFA ULGF for these conditions is 2.3 MHz and the additional gain in the HF audio band ~8 dB

Observations . . .

- Both topologies exhibit similar uncompensated OL UG intercept Fo's (above 10 MHz in the models used here – typical power amplifier figures)
- Excess phase accumulates less rapidly in CFA's because of the wider OLG/LG bandwidths and lower gains compared to VFA (note: this is *not* the same as saying phase accumulation is a function of gain)
- Conclusion: compensating CFA's for the same ULGF as VFA's on the basis that the OPS are the same and therefore phase shifts are the same will result in sub-optimal performance on the CFA for loop gain bandwidth and hence HF loop gain
- For CFA's, a better method is to explicitly target a specific PM (say 60 degrees or more) at the ULGF
- This will generally result in a higher ULGF for the CFA, and compared to a MC or MIC comp'd VFA, higher loop gain in the CFA in the HF audio band
- Further, efforts to raise the loop gain in CFA topology amplifiers will cause the CFA to exhibit excess phase accumulation similar to that of the VFA, in which case, the ULGF on the CFA will have to be reduced to preserve stability
- This will reduce the HF loop gain advantage of the CFA over the VFA demonstrated here, and responses above the CFA -3 dB LG bandwidth will be the same as the VFA
- Therefore, the CFA power amplifier designer has a choice: target higher loop gains through for example, higher gain VAS/TIS and deal with the excess phase accumulation by lowering the ULGF, or, target reduced loop gain, but higher ULGF and a loop gain advantage of 8-12 dB at HF
- Note that advanced comp techniques like TPC, OIC, MIC ('Alex comp' in CFA since the loop gain derivation is different') can be used by CFA designs.